

Conversion of Four-Leg Minor Stop Control Intersections to Roundabouts

The Massachusetts Department of Transportation (MassDOT) has performed a safety evaluation for conversion of 5 four-leg intersections, with stop-control on the minor approaches, to roundabouts. A typical conversion is depicted in Figures 1 (the before condition) and 2 (the after condition). The intention of this evaluation was to estimate a Crash Modification Factor (CMF) to understand the safety effect of the treatment, along with an economic evaluation to ensure the projects are justifiable financially. Prior to the conversions, 92% of crashes on the sites involved more than one vehicle, with 38% of those classified as a fatal or injury crash. Further, more than half of all crashes were angle crashes, which tend to be more severe than other intersection crash types. A CMF of 0.48 was calculated for multi-vehicle crashes, meaning this crash type can be reduced by 52%, largely driven by an 84% reduction (CMF of 0.16) in multi-vehicle fatal and injury crashes, resulting in an estimated benefit-cost ratio of 8.0:1. **It is estimated that an investment of \$1 million can result in a reduction of 2 fatal or incapacitating injury crashes and 13 non-incapacitating or possible injury over the 20-year lifetime of a treated intersection.**

Background

In MassDOT's 2013 Strategic Highway Safety Plan, intersections were identified as an emphasis area for safety improvement. Intersections were also called out for improvement, along with left turn crashes, as part of MassDOT's 2016 Highway Safety Improvement Program (HSIP). Minor stop control intersections present dangers due to the lack of control on two of the intersection approaches, which puts the onus on vehicles departing from the stop sign for avoiding collisions. The lack of traffic control on two approaches also increases the likelihood of a severe crash as vehicles on the main road involved in collisions are typically traveling at higher speeds.

The Federal Highway Administration considers roundabouts a proven countermeasure for improving safety at intersections. Roundabouts increase the safety of four-leg intersections by reducing conflict points, points at which two vehicles have the potential to collide based on vehicle movement paths. A typical four-leg intersection, allowing all movements, has 32 conflict points between vehicles; whereas, roundabouts have only eight. Figure 3 depicts these conflict points graphically. Previous safety evaluations in the literature found that the conversion of urban four-leg minor stop control intersections to



Figure 1 - Intersection of County Street with Chace and Mason Roads in Freetown, MA prior to conversion to a roundabout (April 2010) [Source: Google Earth]



Figure 2 - Intersection of County Street with Chace and Mason Roads in Freetown, MA after the conversion to a roundabout (August 2016) [Source: Google Earth]

roundabouts typically results in a 30 to 40% reduction in total crashes and an 80 to 90% reduction in injury crashes in other states. For these reasons, along with their operational benefits, MassDOT requires roundabouts to be considered as a form of intersection traffic control during the 25% design stage.

Results

The empirical-Bayes before-after methodology was used to estimate CMFs for roundabout conversions. Five sites were used for analysis, with the intersections located in the towns of Northampton, Barnstable, Lancaster, Freetown, and Sandwich, having an average of 4.2 years of before data consisting of 117 multi-vehicle crashes and 42 multi-vehicle fatal and injury crashes and 2.6 years of after data consisting of 32 multi-vehicle crashes and 4 multi-vehicle fatal and injury crashes. The main roadway at all five sites was an urban minor arterial.

The result of the evaluation was a CMF of 0.16 (with a standard error of 0.08) for multi-vehicle fatal or injury crashes, showing an 84% decrease in crashes of this type. A CMF of 0.48 (with a standard error of 0.10) was estimated for all multi-vehicle crashes, indicating a 52% reduction in multi-vehicle crashes at the intersection. It is projected that there will be a reduction of 159 fatal or injury crashes at these intersections over a period of 20 years.

Because left-turn crashes are a major contributor to the crashes at intersections and intersections are an emphasis area for MassDOT, the effect of roundabouts on angle crashes was also evaluated. This analysis found a CMF of 0.37 (63% reduction) for all angle crashes and 0.07 (93% reduction) for fatal or injury angle crashes.

An economic evaluation was also performed to estimate the benefit/cost ratio of the conversion of four-leg minor stop control intersections to roundabouts. For the five treated sites, it was calculated that over a 20-year period the benefit-to-cost ratio of the roundabout conversion was 8.0 to 1 (assuming a 3% annual discount rate¹, meaning that for every \$1 spent on roundabout conversions, the Department will see a return of \$8.00. It should be noted that these are only safety benefits and do not account for operational benefits accrued from the conversion, as such, the benefit/cost ratio is likely greater than 8.0 to 1.

Discussion

The results of this evaluation are consistent with previous findings in the literature. The reduction in fatal and injury crashes as well as angle crashes proves roundabouts are a successful countermeasure for two of MassDOT's HSIP emphasis areas: intersections and left-turn crashes. These findings also reinforce MassDOT's requirement that roundabouts and their extensive safety benefits be considered as a form of intersection traffic control at the 25% design stage.

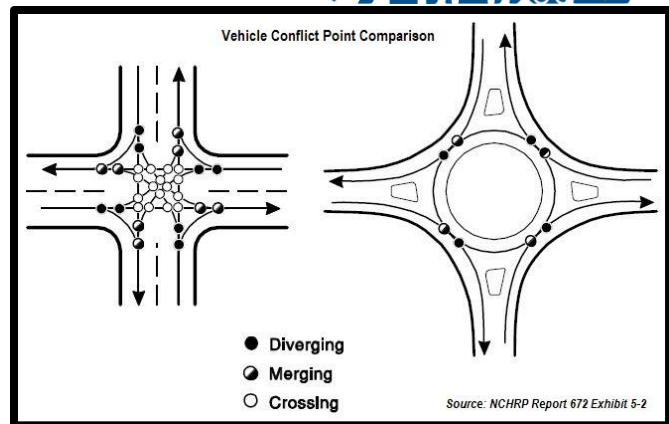


Figure 3 – A comparison of conflict points between a typical 4-leg intersection and a roundabout [Source: NCHRP 672 Exhibit 5-2]

¹ This memorandum has been updated to reflect newly adjusted comprehensive crash costs from FHWA for the state of Massachusetts.